UNIVERSITY OF CALIFORNIA, RIVERSIDE

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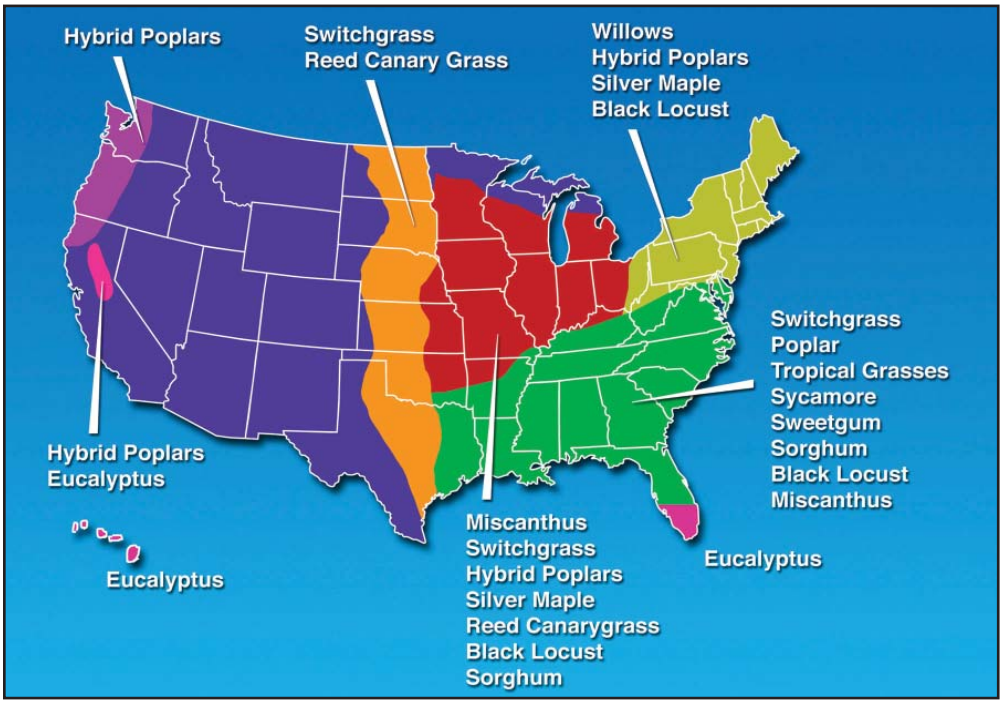


Potential crops by region for production of ethanol from cellulosic biomass

Sustainable Energy Systems Group in $375m Department of Energy program

A CE-CERT group is part of a team just awarded $125 million over 5 years by the Department of Energy to start one of three new research centers.

CE-CERT's Charles Wyman and Bin Yang will be working with post-doctoral scholars and graduate students at UCR on pretreatment of advanced cellulosic plants to understand how to best modify their characteristics for optimal integration with advanced microbial systems for conversion into fuel ethanol.

The Department of Energy award of up to $375 million will fund the creation of three new Bioenergy Research Centers to be located in Oak Ridge, Tn, Madison, Wi, and Livermore, Ca. CE-CERT will be affiliated with the Oak Ridge center. The Centers are intended to accelerate basic research in the development of cellulosic ethanol and other biofuels.

Other partners include the University of Georgia, the University of Tennessee, the National Renewable Energy Laboratory, Georgia Tech University, the Samuel Roberts Noble Foundation, Dartmouth College, ArborGen, Mascoma Corporation, Verenium Corporation, Cornell University, Washington State University, the University of Minnesota, North Carolina State University,

See CENTER, p. 7

Biofuels to be Focus of Research

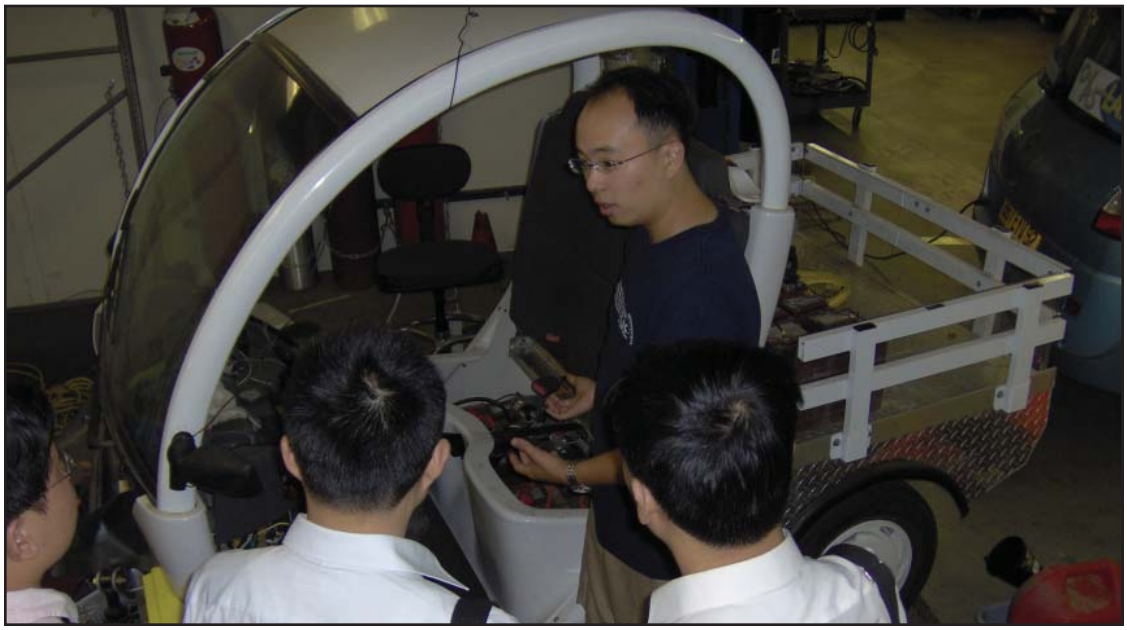
Subjects such as climate change and alternative fuels have risen to the top of the political agenda recently. But for years, researchers at UC Riverside's Bourns College of Engineering have quietly pursued research that makes California's green leadership possible.

When the California Air Resources Board (CARB) announced 40 winners of alternative fuel awards, more than half of the $3.3 million in the category of fuel research came to CE-CERT's Emissions and Fuels group. The CE-CERT research will examine the air quality impact of various biofuels alternatives being considered by state agencies. The South Coast Air Quality Management District (SCAQMD), the Los Angeles basin's smog agency, will help fund the studies.

In June, Governor Arnold Schwarzenegger announced a pilot biodiesel program underway with the California Department of Transportation (Caltrans). The project tests the feasibility of converting the

See BIOFUELS, p. 8

News



Graduate student Henry Chen explains CE-CERT's program in autonomous vehicles to visitors from Shanghai Jiao Tong University. The two schools alternate annual visits of faculty and students. This year's two-day visit to CE-CERT included tours, research presentations and a celebration dinner.

New Research Staff Added

Simone Brethauer and Manishkumar Shrivastava joined CE-CERT as post-doctoral researchers.

Brethauer joined the Sustainable Energy Systems Group and will be working with Dr. Charles Wyman on pretreatment of cellulosic material for the production of ethanol. She received her Ph.D. in April from the Swiss Federal Institute of Technology Zurich with a thesis titled "*In situ* product removal as an approach to improve the fermentative production of clavulanic acid." She earned her undergraduate degree in Chemistry at the University of Hannover, Germany.

Shrivastava joined the Emissions and Fuels Group working with Dr. Heejung Jung on emissions from diesel engines. He received his Ph.D. in August from Carnegie Mellon University in Pittsburgh with a dissertation on "Understanding sources and behavior of primary organic aerosol emissions in the atmosphere: Source and Receptor oriented modeling." He gained a Master's degree from the Indian Institute of Technology (Bombay) after undergraduate work at Bombay University.

Brethauer

Shrivastava

New Administrative Staff Members

CE-CERT's administrative staff was bolstered by several additions during the third quarter.

Glen Kaukola was confirmed as Systems Administrator, a position he'd been filling on an interim basis. Glen had previously been a programmer for the Emissions Modeling Group.

Amanda Raymer was appointed as the assistant to the Director. Amanda had been with UCR's Human Relations Department.

Lisa Gonzalez joined the staff as Human Relations and Purchasing Assistant. She had been with the Fire Department of the city of Moreno Valley.

Valerie Thomas came aboard as a Budget Assistant. She had been with Farmers Insurance.

Beverly Martinez took over as CE-CERT's receptionist and travel coordinator. Beverly succeeded Suzanne Sutphin, one of the Center's longest tenured employees. Suzanne is enjoying retirement.

How Effective are HOV lanes in Improving Air Quality?

A Modeling Approach

By KANOK BORIBOONSOMSIN
and MATTHEW BARTH

In the past decade, there has been a growing concern nationwide regarding the effectiveness of high-occupancy vehicle (HOV) systems in meeting their intended goals. As a result, many states have improved their performance monitoring programs and periodically conduct performance evaluations of their HOV facilities. In California, the effectiveness of HOV lanes was reviewed and discussed in a report by the Legislative Analyst Office in 2000. One of the key comments from the report was that the benefits of HOV lanes concerning air quality were unclear and needed further investigation. Following this legislative report, two HOV lane performance evaluation studies were conducted in Southern California. Due to the large scope of these two studies (i.e., an evaluation of many aspects of HOV lanes), the benefits and impacts regarding air quality was left unanswered. As a result, Caltrans was facing an increased number of challenges by the general public, environmentalists, and policy makers regarding the justification of building and operating HOV lanes. It was determined to carry out a specific evaluation of HOV lanes that focuses on the air quality aspect together with a scientifically sound modeling toolset that provide reliable estimates of the air quality impacts of HOV lanes. This modeling toolset will then assist Caltrans to better respond to the air quality questions raised about HOV lanes.

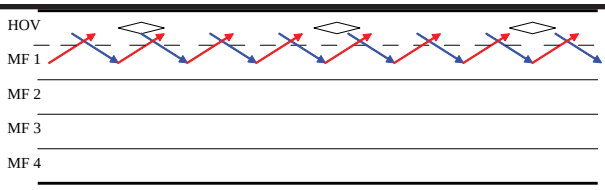
In 2005, the University of California, Riverside's Center for Environmental Research and Technology (CE-CERT) was asked to evaluate HOV lanes' air quality impacts. The overall goal of the project was to evaluate the air quality benefits of existing HOV lanes in California and develop a public domain modeling

toolset that can be used to provide reliable estimates of the air quality impacts of HOV lanes. The development of the modeling toolset consists of two major components:

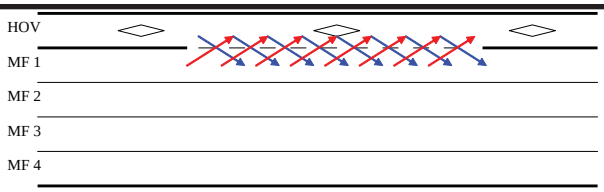
1) A **mid-scale modeling tool that can be used for regional planning-level air quality analyses**. This tool is based on a top-down approach that uses existing mobile source emission factor models (i.e. California's EMFAC and U.S. EPA's MOBILE) along

with appropriate correction factors derived in this study; and

2) A **microscopic modeling tool developed using a bottom-up approach** that uniquely combines a traffic simulation model with a comprehensive modal emissions model. Overall, the goals of the project have been accomplished and several conclusions were developed, as described below.



Continuous access between High Occupancy Vehicle and Mixed-Flow lanes, the Northern California model.



Limited, periodic access between High Occupancy Vehicle and Mixed-Flow lanes, the current Southern California model.

An evaluation of HOV-lane air quality benefits/impacts was performed by comparing the emissions from HOV lanes vis-à-vis their mixed-flow (MF) lane counterparts. Representative driving data samples from both lane types were collected on selected freeways and then used as input to a state-of-the-art modal emissions model to estimate the resultant emissions. The driving was controlled for driver, vehicle, test location, segment length, and environmental conditions so that the differences in emission results were due to only driving and traffic-related factors (i.e. driving speed as well as frequency and magnitude of acceleration/deceleration). The evaluation was conducted separately for HOV lanes in Northern and Southern California because of their different operational characteristics. For Southern California HOV lanes, the emissions comparison was made multiple times under different traffic conditions as esignated by four HOV-lane operation scenarios – under-utilized, neutral, well-utilized, and over-utilized. For Northern California HOV lanes, the emissions comparison was made both when HOV lanes were active and when they were not. (Northern California HOV lanes are unrestricted lanes except for certain hours).

Key findings from this evaluation study are that:

1) Under existing demand conditions, HOV lanes on the freeways produce less pollutant emissions per lane compared to the adjacent MF lanes. This is mainly due to the better flow of traffic in the lanes; and

2) Considering that the average vehicle occupancy in the HOV lanes is approximately double of the average vehicle occupancy in the MF lanes, the HOV lanes are also found to produce far less emissions per traveler. These findings are applicable to both HOV lanes in Southern California and HOV lanes in Northern California when they are active.

Mid-scale Modeling Improvements

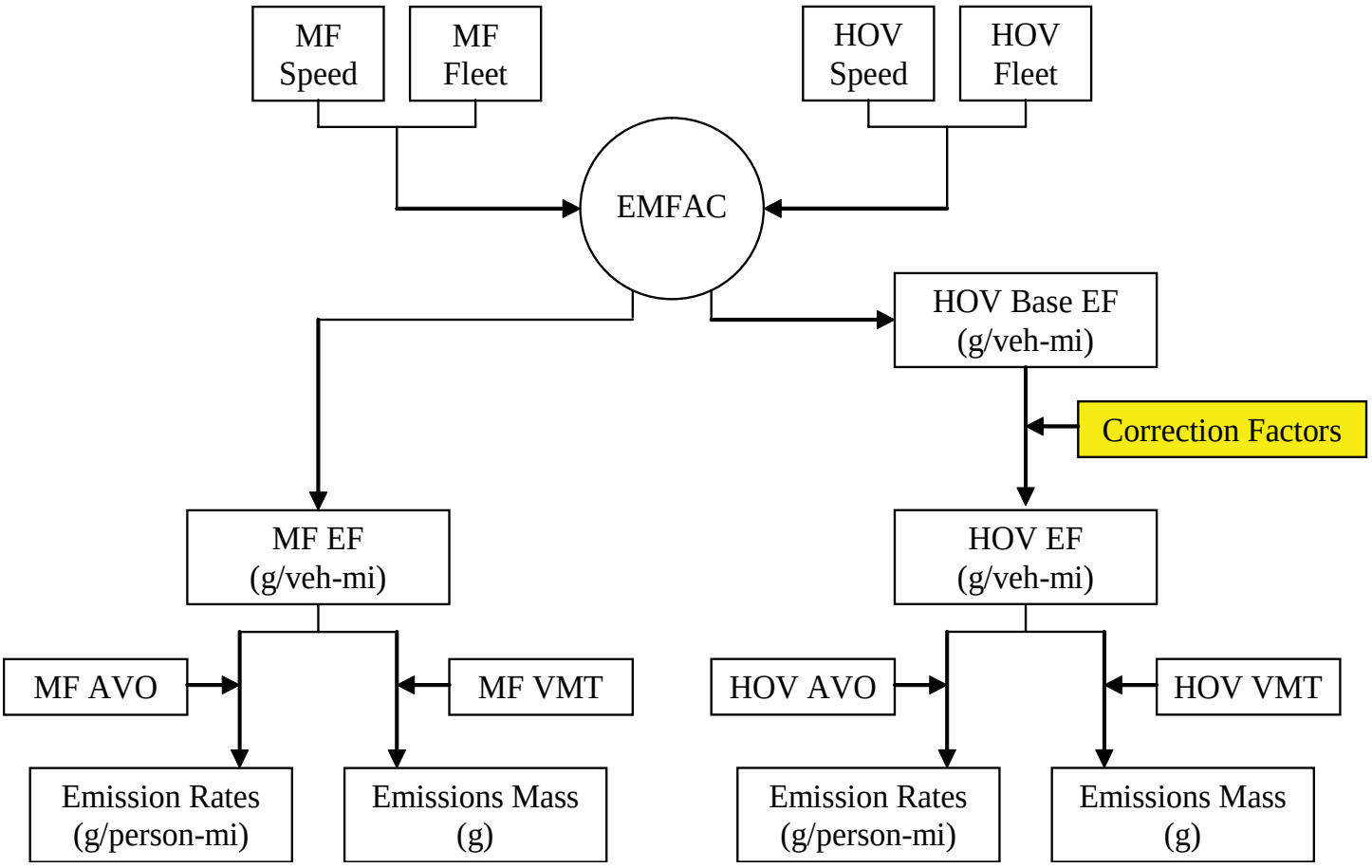
The objective of this task is to make improvements to the emission inventory process for HOV lane facilities. It is well understood that HOV lanes experience higher speeds than MF lanes most of the time, depending on traffic conditions. In order to improve HOV/MF emissions modeling, it is necessary to separately apply speed correction factors for the lane types

Boriboonsomsin

Barth

The CE-CERT study presented here supported the California Department of Transportation's decision to begin reconfiguring HOV lanes in Southern California for continuous access. It has also led to a second, $200,000 project for Drs. Boriboonsomsin and Barth. This project will evaluate the configuration (continuous access v. limited), operating hours and eligibility criteria (3 people or 2) of HOV lanes, with a focus on the configuration and operating period. The policy alternatives in each aspect will be comparatively assessed against each other. This will be performed at various levels of demand, including those projected to the future, to determine which policy alternative would be better for each level of demand.

Modeling Procedure



MF = Mixed-Flow lanes; Fleet = the distribution of vehicle types; HOV = High Occupancy Vehicle lanes; EMFAC = short for Emissions Factor, a modeling tool; EF = Emissions Factor expressed in grams of emissions per vehicle mile traveled; AVO = Average occupancy of the vehicle; VMT = Vehicle Miles Traveled. Emission Rates calculates the emissions based on grams per person-mile traveled while Emissions Mass quantifies the absolute amount of emissions.

within the regulatory emissions factor model EMFAC. In addition to speed, there are other factors contributing to emission estimates that need to be examined for differences between HOV and MF lanes. These factors include driving trajectory and fleet composition.

To examine the differences in fleet composition, a sample of more than 3,000 license plate numbers from vehicles running in both lane types were collected from three selected freeways. These anonymous license plates were then matched with a partial Department of Motor Vehicles (DMV) vehicle information table as of December 2005 to extract information of each individual vehicle. The information regarding vehicle model year was used to perform statistical tests for difference between the two fleets. It was found that there was no statistically significant difference between the distributions of vehicle model year in HOV and MF lane on three sampled freeways.

To examine the differences in driving trajectories (i.e., speed versus time profiles), a database of driving trajectory data for both HOV and MF lanes was compiled along with level of service (LOS) congestion information for a variety of freeways. The data were then grouped according to the designated LOS before statistical analyses were performed. According to the statistical analysis results, it was found that traffic dynamics (as described by speed, acceleration, and road load power) in HOV lanes were significantly different from those in MF lanes at every congestion level. When calculating the emissions corresponding to these data sets, it was found that the average emission rates in the two lane types could be different by as much as 20% for both carbon monoxide and carbon dioxide. These results warrant the development

of lane-specific emission-correction factors for HOV lanes.

The development of lane-specific emission correction factors for HOV lanes was based on finding the ratio of HOV lane emissions rates to MF lane emissions rates at the same average vehicle speeds. First, HOV and MF emission rates were plotted as relative to the average speeds associated with each congestion level. Then, a parabolic curve was fitted to each data set to represent speed correction factors for each lane type. The goodness of fit of these curves is considered very strong as the coefficients of determination (R2) of the associated equations are in the range of 0.84-0.97. Using the equations, the ratio of HOV emission rates to MF emission rates at different levels of average speed for each pollutant was computed. These ratio values can be used as HOV lane emission correction factors by multiplying them to freeway emission rates to obtain emission rates specific for HOV lanes. These factors allow modelers to adjust the emission rates for HOV lanes to properly reflect the acceleration/deceleration characteristics of HOV lane operation at different traffic conditions, thus resulting in more accurate emission estimates.

Microscopic Modeling Demonstration

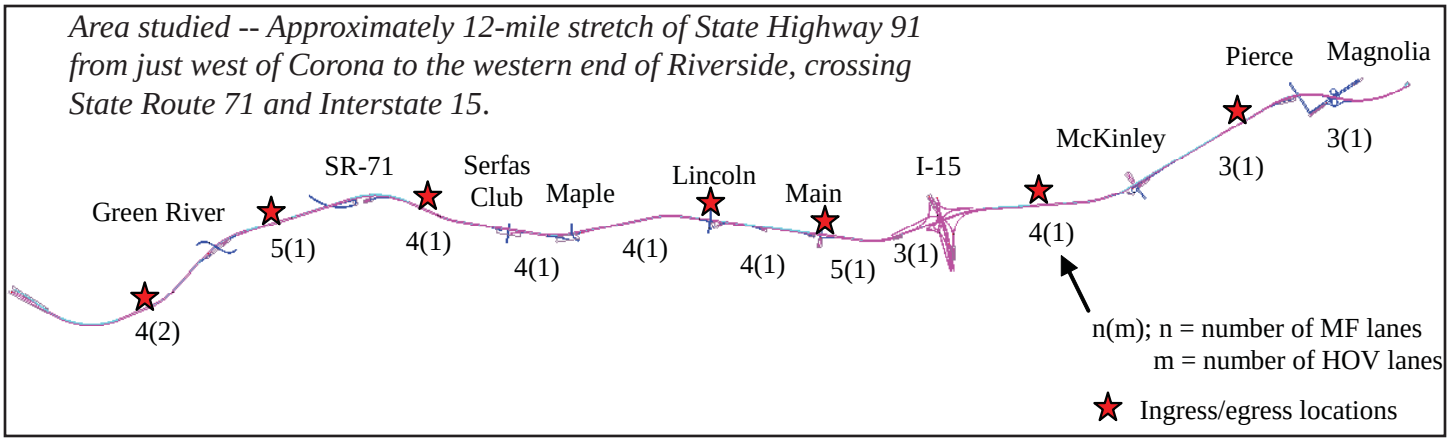
The objective of this task was to demonstrate the deployment of an integrated microscopic traffic simulation and modal emissions modeling tool to evaluate air quality benefits/impacts of HOV lanes at corridor-specific levels. A freeway section in Southern California was used as a case study to conduct analyses in response to the question "how should the innermost lane of this freeway section be used effectively?" Three lane configurations were modeled and the resulting pollutant emissions were compared. These lane configurations are:

1) Southern California style HOV lane (limited access)

2) Northern California style HOV lane (continuous access), and

3) a standard mixed flow lane.

First, the coded model network, demand, and other model parameters went through an extensive verification and validation process, following Caltrans' guidelines, to ensure the model appropriately replicated the existing roadway and traffic conditions. Next, the model was used to analyze multiple what-if scenarios and to conduct numerous sensitivity analyses with respect to changes in demand and HOV proportion in the traffic mix. Lastly, an investigation of the modeling results was performed on a case-by-case basis in order to better understand the reasons behind these results.



Conclusions

One of the key findings is that under the same travel demand and percentage of HOVs in the traffic mix, the limited access HOV lane (Southern California style) produced more pollutant emissions than the continuous access HOV lane (Northern California style). This is a result of highly concentrated lane changing activities over the limited length of the provided ingress/egress sections. With this constraint, the HOVs often have to conduct a variety of driving maneuvers such as slowing down to wait for an acceptable gap in the adjacent lane, accelerating aggressively in order to take the gap ahead of them, or making a forceful merge into the adjacent lane, causing the following and surrounding vehicles to brake unexpectedly. These maneuvers not only affect the driving pattern of those HOVs themselves but also influence the driving pattern of other vehicles in the mainstream

See HOV, p. 7

3rd Quarter research awards top $4.6 million

Led by major awards to the Sustainable Energy Systems Group and the Emissions and Fuels Group, CE-CERT won $4.6 million in research contracts and grants during the third quarter.

The Sustainable Energy Systems Group was part of a consortium that will share a $375 million award from the Department of Energy to study biofuels. (See p. 1 for more details). The group's share will be $1.994,350 over five years and the research will focus on Biomass characterization and pre-treatment research of cellulosic feedstocks for ethanol production. Materials such as corn stover, poplar trees and switchgrass have all been discussed as possible feedstocks.

The Emissions and Fuels Group won $1.28 million from the California Air Resources Board to study the air quality impact of switching the equipment fleet of the California Department of Transportation to biofuels. (See p. 1 for more details). The switch is being contemplated as part of Governor Arnold Schwarzenegger's campaign to lower California's contributions to global warming.

Dr. Wayne Miller, manager of the Emissions and Fuels Group, earned a $500,000 addition to funding for his research on emissions at the ports of Los Angeles and Long Beach. This work is the first major research on the air quality impacts of port operations, a field Miller has pioneered.

CE-CERT Director Dr. Matthew Barth won a $400,000 contract from the California Air Resources Board to determine the quality and breadth of data on carbon dioxide emissions in the state and to develop methods for improving the data.

HOV, from p. 6

traffic in all lanes. As a result, the frequency and magnitude of acceleration/deceleration and thus emissions of vehicles on this section are relatively high.

According to the what-if scenarios tested, it was found that for the existing conditions on the simulated freeway, the conversion of the Southern California-style HOV lane to another MF lane will provide an emission benefit (emissions/total demand) if it induces vehicle travel demand of less than 5% onto the freeway. Similarly, the conversion of the continuous access HOV lane to another MF lane will provide emission benefit if it induces vehicle travel demand for less than 2% onto the freeway. These are minimum criteria considering all pollutants analyzed (CO, HC, NOx, and CO2). However, if HOV lanes are converted to MF lanes, it is highly likely that vehicle travel demand will increase, due to former carpoolers splitting and generating additional vehicle trips to meet the travel needs. As a result, emissions will certainly increase.

Kanok Boriboonsomsin is a post-doctoral scholar in CE-CERT's Transportation Systems Group. He received his Ph.D. from the University of Mississippi and has specialized in transportation engineering issues. Matthew Barth is CE-CERT's director, manager of the Transportation Systems Group and a professor of electrical engineering at the University of California, Riverside.

CENTER, from p. 1

Brookhaven National Laboratory, and Virginia Tech University.

The different partners will bring their varying areas of expertise to bear on the issues related to more efficient ethanol production. The issues range from the best feedstock sources to the production process.

Wyman and Yang, who are part of the Sustainable Energy Systems group at CE-CERT, concentrate their research on the enzymes and other elements used in the pre-treatment of cellulosic plant material.

A major goal of the Department of Energy's program is to move ethanol production away from edible corn as the feedstock. Agricultural residents (such as the non-edible parts of the corn plant), grasses, poplar trees and inedible plants are all possibilities.

The mission of the Bioenergy Research Centers will lie at the frontier between basic and applied science, and will maintain a focus on bioenergy applications, the Department said. These Centers aim to identify real steps toward practical solutions regarding to the challenge of producing renewable, carbon-neutral energy. At the same time, the Centers will be grounded in basic research, pursuing alternative avenues and a range of high-risk, high-return approaches to finding solutions. To some degree, one key to the Centers' success will be their ability to develop the more basic dimensions of their research to a point that can easily transition to applied research.

BIOFUELS, from p. 1

14,000-strong Caltrans fleet to a biodiesel fuel blend. If the first 20 vehicles pass the pilot test, as determined by CalTrans and CE-CERT, fueling the fleet could save the state up to 600,000 gallons of petroleum annually. Only minor modifications are needed to transform the 230 diesel fuel sites statewide into biodiesel fuel dispensers.

The researchers behind these and similar green projects are Thomas Durbin and J. Wayne Miller, members of CE-CERT's Emissions & Fuels Group. Miller is manager of the Group and Adjunct Professor in the Department of Chemical & Environmental Engineering. Durbin manages CE-CERT's Mobile Emissions Laboratory, Vehicle Emissions Research Laboratory and Heavy Duty Dynamometer facility. They are joint Principal Investigators for the Caltrans and CARB projects.

The Emissions & Fuels Group conducts research on emissions from various engines in the lab and field, under both controlled and real-world operating conditions. Engines of all sorts have been studied, including those in trucks, trains, oceangoing ships, and aircraft. The group's leadership in emissions measurement research, as well as unique technologies and novel methods to do so have attracted partnerships with not only California agencies, but also the U.S. Environmental Protection Agency (EPA), engine manufacturers, commercial engine users and the ports of Los Angeles and Long Beach. Interest in their research is high and the Emissions & Fuels Group has garnered the most external funding of all five CE-CERT groups over the past three years.

Durbin has been Associate Research Engineer at the center since 1994. With B.S., M.S. and Ph.D. degrees from UCR's Bourns College of Engineering, he has published and presented extensively on the emissions effects of biodiesel and other alternative fuels. Durbin is a leading expert in diesel fuel formulation, equipment operability and emissions.

Miller has been with the center since 2000. Prior to joining UCR, he was Vice President for Technology and Product Development for Sunoco. He is widely published on fuels-related research and technology acquisition. He received his B.S. from Worcester Polytechnic Institute and a Ph.D. from Caltech, both in Chemical Engineering. He was a member of the Joint Strike Fighter Emissions Test Development Team that was awarded a 2007 Climate Protection Award from the EPA.

UCR | College of Engineering- Center for Environmental Research & Technology
1084 Columbia Ave.
Riverside, CA 92507